# paving the way for service providers to quickly monetize 5G

## Laying the foundation for enabling 5G services

**A joint solution from Amdocs, Intel, Mavenir, Radisys and Wind River**

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# why network virtualization is a key enabler for 5G services monetization

Communication service providers (CSPs) face the continuing challenge of declining revenues as innovative over-the-top (OTT) services claim a growing share of consumer spend. With increasing user sophistication and customer demands, as well as higher expectations overall, CSPs are responding by enhancing their focus on customer experience. They're doing so by employing digital technologies and developing capabilities that enables them to provide a seamlessly integrated complex array of offered services.

Meanwhile, the ubiquitous use of mobile devices combined with the explosive growth in bandwidth demand is creating dense and complex networks that involve an ever-increasing number of network elements and services. Customer demand for data – especially streaming video, which according to Mavenir comprises 80% of mobile traffic – means that networks must grow rapidly. By leveraging new virtualized network architectures, CSPs will be well-placed to address these challenges.

However the complexity of the network could present a potential show-stopper, as CSPs remain burdened by the need to deploy and manage different purpose-built hardware network components, which are often sourced from different suppliers.

Arguably, innovation is one of the biggest victims. When new hardware features are needed, it takes a long time to implement them into the vendor development program. In many cases, it also requires major and painful hardware upgrades. Network scaling presents its own set of issues: while the network must be built to handle peak demands, off-peak hours can see hardware sitting idly and generating zero revenue (indeed, 50% or more of a mobile network can be idle at one time). Furthermore, with the same standard network appliances being available to all CSPs, the capability to offer differentiation is considerably limited. The result is missed revenue opportunities due to the inability to bring services to the market fast enough.

The solution lies in the impending emergence of 5G technologies, which offers the promise of ultra-low latency and higher mobile broadband applications and use cases. This will empower CSPs to leverage their natural advantages to the maximum – allowing them to introduce new use cases, monetization and business models.

In tandem, network functions virtualization (NFV) is being increasingly recognized for its power to maximize network assets and utilize software-based services in order to acquire the infrastructure agility that is needed to deliver customer value and increase revenues. And while virtualization has for some time been a feature of the back end and network core, its current move toward the RAN (radio access network) and network edge will be a strong enabler for 5G to fulfill its promise.

So for CSPs to be competitive, able to innovate and bring new business offers and services to market quickly, the optimal path forward lies in the transition to software-defined programable networks running over general purpose servers, based on open standards. The benefits will then flow through lower operational costs and improved network ROI, while providing an open software-driven network.

Furthermore, with the new NFV-based open network, CSPs will be able to utilize software from many different vendors in the various network domains, layers and functions, as well as open-source components without compromising on performance. And by transitioning more of their network elements into virtual functions, it will enable them to create an open, agile platform that supports the introduction of software-driven services that accelerate innovation.

# mobile network domains transformation

To get to the 5G future that we envision, the mobile network domains will all transformed to be flexible without compromising on throughput and bandwidth requirements. Network elements must be scalable and agile so that services can be brought up and down quickly, as required by user-generated demand. This will be achieved by Software-Defined Networking (SDN) and Network Function Virtualization (NFV) as well as using well-designed software stacks for the core, edge and RAN – supported by hardware designed to have the flexibility needed to enable traffic to be classified, sliced, and monitored – is the best way to transform networks and make them ready for 5G.

### Virtualizing the RAN: foundations of the 5G wireless network

The new NFV-based open network that enables CSPs to quickly instantiate new services on the path to 5G is based on Intel's FlexRAN reference architecture. The technology was created to speed the path to commercialization for the vRAN (virtualized Radio Access Network) – a key ingredient necessary to reach the many promises of the 5G network.

By virtualizing the RAN, CSPs can reap the following benefits:

- Coordination, centralization and virtualization in mobile networks
- Enablement of new services at the network edge
- Support of resource pooling (more cost-efficient processor sharing) and load balancing
- Scalability (more flexible hardware capacity expansion) from high-capacity cells to low-capacity cells
- Layer interworking (tighter coupling between the application layer and the RAN)
- Support for different front-haul splits as they evolve
- Technology gains such as spectral efficiency

The FlexRAN reference architecture provides foundational hardware based on Intel Xeon processors and Intel FPGAs for best-in-class performance, while also providing the agility that CSPs require based on the specific network requirements and service level agreements of today and tomorrow.

In addition to the proven hardware upon which the FlexRAN architecture is built, Intel and key partners have integrated various software components to support centralized, distributed and integrated RAN configurations as required by CSPs. These software components include BBU (Base Band Unit) software to support both 4G LTE and 5G implementation as follows:

- Layer 1 (PHY) provided by Intel
- Layer 2 + 3 stacks provided by Radisys Corporation

To reduce latency and maximize throughput, the FlexRAN architecture leverages the best from the open source community while taking advantage of integrated Intel technologies in the networking arena. By utilizing the open source Data Plane Development Kit (**DPDK**) for packet processing, data speeds can be increased eight-fold. Intel Quick Assist Technology (**Intel QAT**) can also be implemented on chip or via add-in card, and can free up processor resources by offloading crypto acceleration and compression capabilities. Ultimately, this enables the virtualized RAN to drive performance of wireless communication services far beyond the those achieved by conventional RAN, while significantly reducing operational expenses.

## Virtualizing the EDGE: open the door to new types of applications

Multi-access edge computing is an industry initiative to open up the radio access interface for services and applications in the radio access network (RAN). This location on the network edge offers an environment with many benefits for both the CSP and the end user, including low latency, high bandwidth and direct access to radio information such as subscriber location. Due to the proximity of the edge server, responsiveness to applications and services is increased, thereby improving the quality of experience.

The Intel Network Edge Virtualization (NEV) SDK is the first kit of its kind to provide an NFV platform targeted for mobile-edge computing application and services. The NEV SDK includes an Intel Atom or the new Intel Xeon processor-based server that is fully configurable with real-time virtualization software and Intel's edge computing reference libraries for directing radio traffic information to the virtual machines based on policy settings. The NEV SDK comes with a full tool suite for testing and profiling the applications. The chart below details the components in the SDK.

| NEV SDK | MODULE | DESCRIPTION |
|---|---|---|
| **MEC REFERENCE LIBRARIES** | Network Traffic Services (NTS) | Processes the packets between the eNB and the EPC over the S1 interface. Including IP identification, routing, and GTP decapsulation and encapsulation. This shields the application layer from the lower transport layer 4G protocols used to transfer data on the S1 interface. |
| | Network Edge Services (NES) | Responsible for interfacing with the VM, and service registry. |
| | Network Information Services (NIS)1 | Extracts and stores radio network information, and provides it to the upper layer applications via the NES. |
| | NES API1 | Interfaces with the MEC applications to provide services. |
| **WIND RIVER® TITANIUM CLOUD™** | Accelerated Virtual Switch (AVS) | Provides communications between applications running on different Virtual Machines (VMs) and significantly increases packet throughput. |
| | Open Virtualization Platform | A fully integrated, highly optimized, and secure carrier grade application-ready software solution. This platform delivers a lower cost solution that is capable of supporting the high throughput, low latency, and deterministic requirements for 5G networks traffic. |
| | OpenStack virtualization management | Removes the need for the application developer to set up the virtualization environment. |
| **DATA PLANE DEVELOPMENT KIT (DPDK)** | Open source | A set of libraries and drivers that optimizes packet processing on Intel® Architecture (IA). |
| **INTEL® APPLICATION DEVELOPMENT TOOLS** | Intel® System Studio 2015 also available in 90-days license. | Tools that enable the developer to accelerate product development, optimize performance, and debug code. |

Table 1: Intel NEV SDK components

By utilizing the NEV SDK in conjunction with the Intel FlexRAN reference architecture, the 5G Infrastructure reference design provides CSPs with a quick and efficient way to jump start their implementation of a virtualized RAN with edge services for today's and future 5G networks.

## Virtualizing the core: removing key barriers to scalability and agility

Moving to a virtualized evolved packet core (vEPC) enables CSPs to quickly react to market changes, while reducing backhaul costs and time to market by simplifying deployment, interoperability and optimization. Mavenir's vEPC transforms networks through a highly scalable design that can adapt to many 4G LTE deployment use cases and is natively extensible to emerging 5G standards. This approach eliminates the expensive hardware, long upgrade cycles, overprovisioning, and years-in-advance budgeting that is traditional for wireless networks. CSPs can therefore offer services to both 4G and 5G subscribers, and scale to support multi-access edge computing (MEC) use cases on small form factor and white box solutions with zero-touch orchestration.

Mavenir's vEPC is specifically designed from the ground up for virtualized environments, using a service-based, horizontal architecture consisting of independent interface, service logic, database and management modules (Figure 1). This holistic approach to functional virtualization optimizes performance and efficiency compared to the traditional approach of replicating existing physical nodes as a software asset—and is the fundamental difference between Mavenir's vEPC and other virtualized products. Mavenir has built next-gen virtualization with the use of containers, thereby addressing CSPs' web scale network requirements. The vEPC provides a robust, high-performance, scalable and fault-tolerant solution capable of supporting diverse use cases.

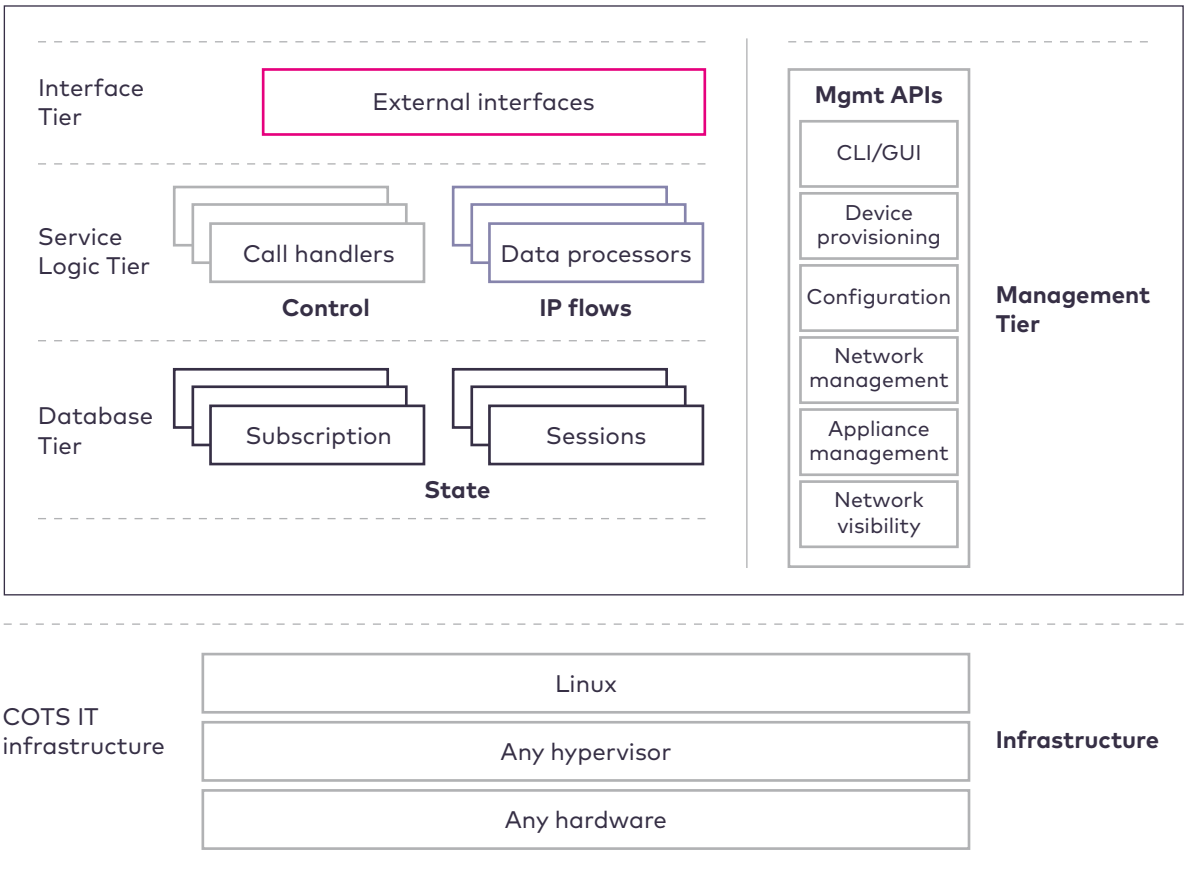


Figure 1: vEPC Logical Architecture. Source: Mavenir

# end-to-end 5G network services orchestration

End-to-end orchestration is a critical component in the optimization of resource utilization in virtualized networks. By virtualizing functions, operators can free their networks from the constraints of legacy networks and create an environment that provides endless opportunities to innovate operations and services.

The orchestrator is hierarchically positioned at the top of the end-to-end network to coordinate RAN, edge and core network operations and services. The purpose of orchestration is to standardize the way virtualized functions are managed and optimize network resource utilization across all the network domains (e.g. RAN, edge, core and data center). It ensures that virtualized functions are instantiated, managed efficiently, and that they can coexist efficiently with the legacy portion of the networks.

The above represents the critical role played by Amdocs NFV powered by ONAP's (Open Network Automation Platform) end-to-end service orchestration, which manages the coexistence of functions, while ensuring that resource allocation meets the service needs of the operator. It is also responsible for ensuring the end-to-end service and network traffic by orchestrating network service-related lifecycle management activities such as scaling, policy management, administrative operations and assurance.

As a unified and centralized platform for onboarding VNFs and creating network services, it enables service creation automation, testing and debugging, as well as packaging and distribution. This in turn, shortens the service development lifecycle and reduces engineering and IT costs.

For each service defined, the platform associates definitions, processes and policies for management and execution of that service. Once the service activation is triggered by the BSS, Amdocs NFV powered by ONAP service orchestrator instantiates the necessary VNFs and network connections from end to end across the different network domains. This enables it to deploy the service into the network by interacting with infrastructure, network and application controllers as required.

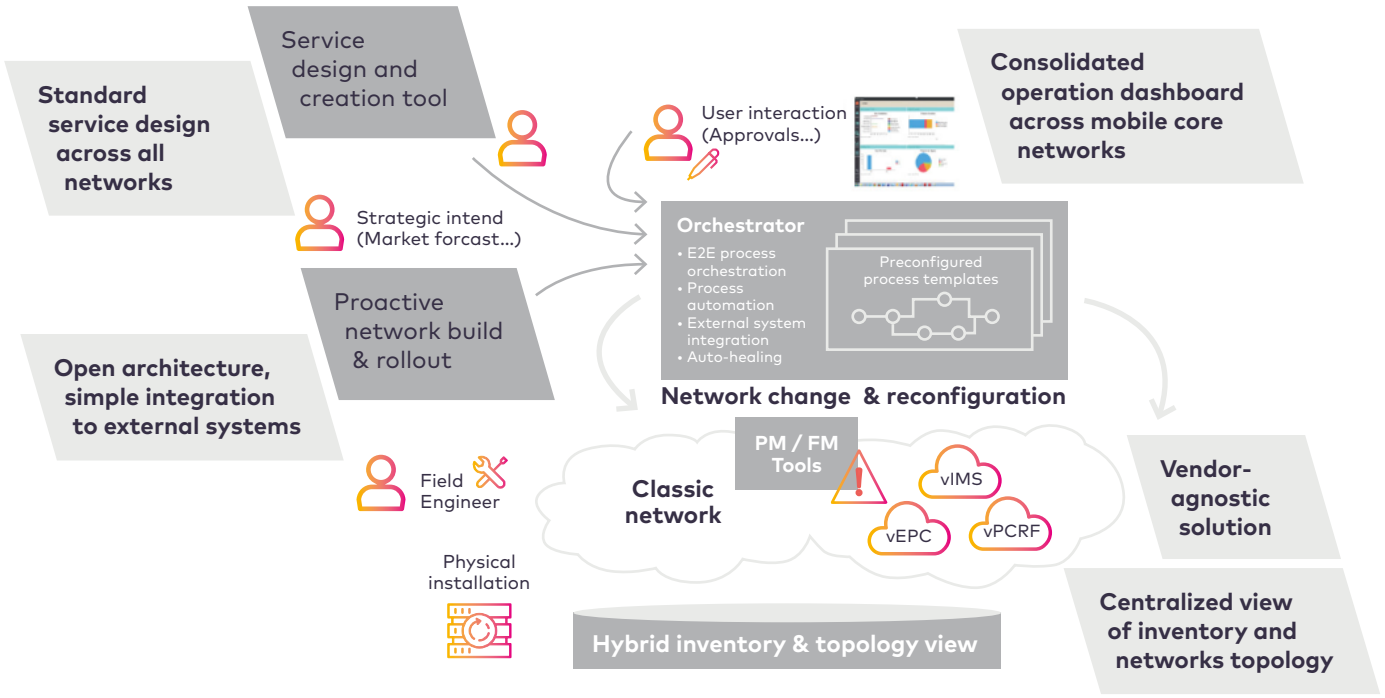


Figure 2: Key features of Amdocs NFV powered by ONAP

The above diagram illustrates how Amdocs NFV powered by ONAP provides a unified and consolidated view of network functions, resources and topology, real-time conditions and monitoring, and consolidated control tools. Its closed-loop service automation analytic framework closely monitors service behavior during the service lifecycle by collecting data and performance indication from physical and virtual elements (compute, storage and network) across the network infrastructure.

The system policy engine triggers healing and scaling of resources to elastically adjust to demand variations based on the specified design, as well as analytics and policies to enable the necessary response to ensure the service meets its committed service agreement. The service orchestration selectively adds and remove functions, services and resources with zero touch, by leveraging automated processes for deploying and performing ongoing management of services from end to end across all CSP network domains.

Moreover, the platform's flexibility and openness to operate in complex environments enables it to fulfil its critical role of orchestrating multiple network functions to obtain an end-to-end service path. At the same time, it enables it to be vendor-agnostic so that CSPs can deploy functions from any vendor in various network and cloud domains. This new reference design delivers efficiencies that accelerates deployment of revenue-creating services to both businesses and consumers. As a result, and by allowing CSPs to centralize the management of network resources with dynamic workload processing and unified cloud orchestration, it provides a fast path to 5G.

Amdocs, Intel and Mavenirs' dedicated teams of architects, software engineers and validation specialists pre-integrated tested and validated the proposed 5G reference architecture design, thereby enabling CSPs to accelerate the deployment of new services and jumpstart their development of edge computing and services. This, combined with its pre-integrated components and proven interoperability, will enable customers to leverage their new 5G networks to both shorten their time to market and reduce their costs.

# multi-vendor pre-integrated 5G virtual network solution

Transforming the network into a software programable network requires the network infrastructure to first have server features embedded for hosting the application software. Once this is achieved, the operational network processes must be able to handle a higher rate of change and have the flexibility to deploy network functions and applications at the most appropriate location in order to achieve the highest performance and cost savings. The goal is to enable a new service-driven network by making the network service-aware and agile as opposed to the legacy focus on connectivity and capacity.

To achieve this, VNFs workloads must properly utilize the underlying hardware processing, storage and networking capabilities. In addition, VNFs must also self-heal and automatically scale when traffic loads increase across the different network domain, in order to guarantee end-to-end service availability in accordance with real-time service requirements and commitments.

To answer this need, Intel, Mavenir and Amdocs partnered to create a rich, pre-integrated set of VNFs, infrastructure management tools and service orchestration platform that spans the RAN, edge and core network domains. The result is a 5G reference design that serves as a blueprint for CSPs to rapidly deploy a software-defined, cloud-enabled, agile 5G-ready network that supports use cases including virtual, merged and augmented reality, smart retail, industrial automation, IoT and cloud gaming.

Intel's FlexRAN and NEV SDK run on Wind River's Titanium Cloud virtualization environment and are orchestrated by Amdocs NFV orchestrator in the 5G Reference Design, which is optimized for low latency and includes:

- Wind River's accelerated virtual switch (AVS), which is based on open source Open Virtual Switch (OVS-DPDK) hardened for low latency by Wind River
- A fully integrated, highly optimized, open and secure carrier grade application-ready software solution
- Wind River's OpenStack distribution for cloud infrastructure management, which is hardened for low latency

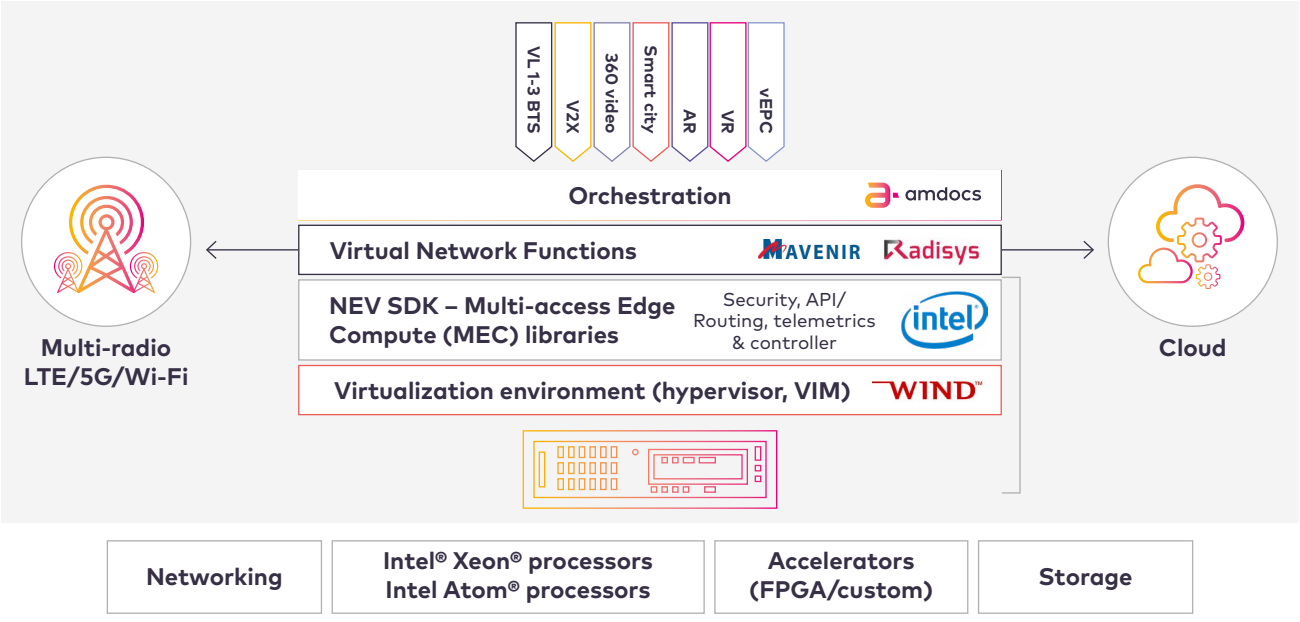




Figure 3: Intel 5G infrastructure reference design building blocks

# 5G monetization use cases

### Use case 1: leveraging ultra-low latency provided by the edge cloud for unique QoE

Today's networks already allow many applications and services to be run, while simultaneously sending data to the cloud (upstream) for analysis and be returned (downstream) in a matter of seconds. Yet, while this setup may be sufficient for those applications that do not require real-time or near real-time responsiveness, 5G will greatly enhance these current experiences. In addition, it will provide the ability to bring new services to life that will require ultra-low latency such as autonomous driving, VR/AR/mixed reality and various medical-related applications such as tele-surgery.

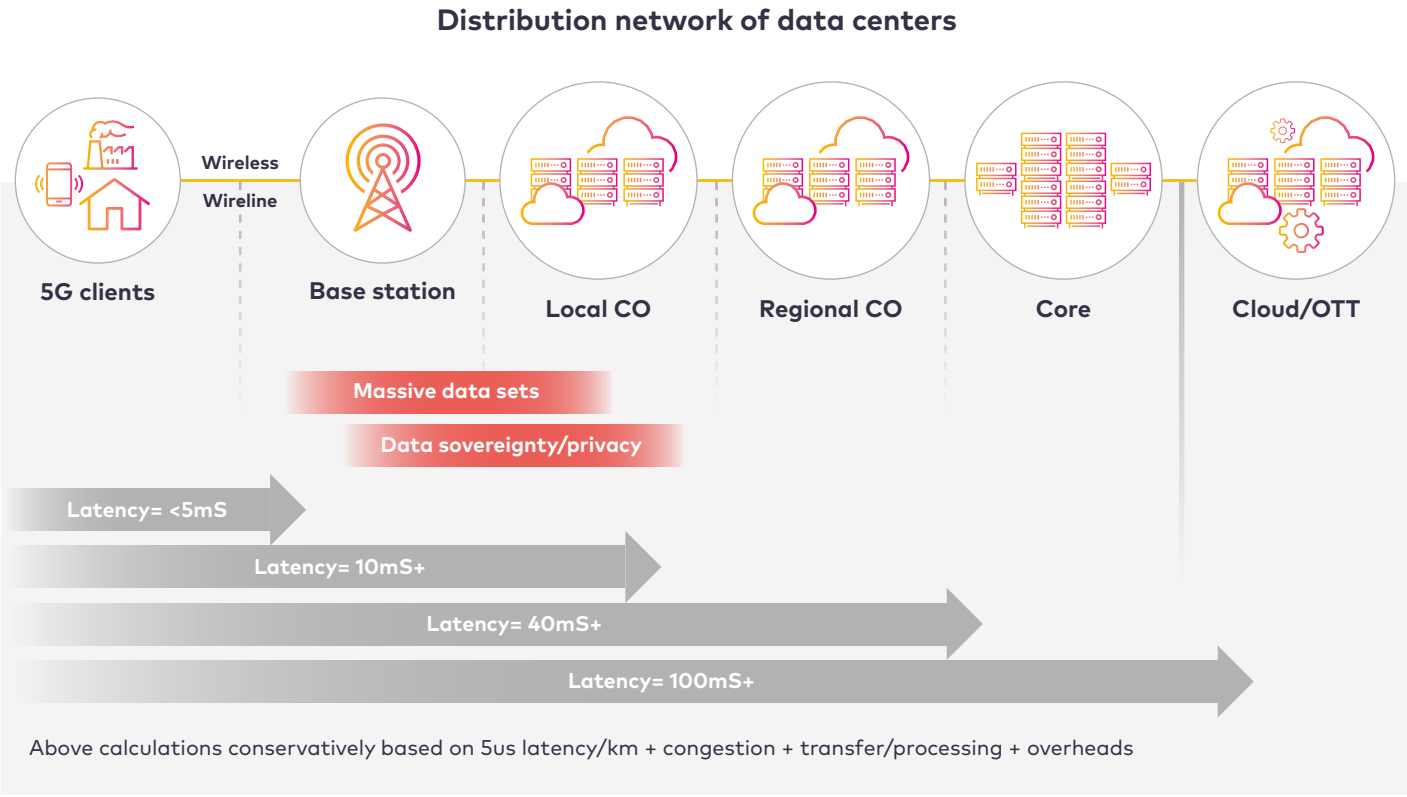


Figure 4: Expected latency based upon the path traversed from device to cloud (Source: Intel)

One of the many use cases that can be serviced by the Intel Infrastructure Reference Design is the deployment of an edge cloud application that can provide the ultimate end user QoE (quality of experience). Indeed, QoE will be a major requirement of end users in the 5G era as CSPs continually work to provide new revenue-producing content, applications and innovative services that will entice consumers to purchase or sign up for more.

Already, such QoE is available in applications such as AR/VR and live gaming, as well as any type of spectator-viewing applications such as sports, concerts and smart stadium venues. This answers consumers' demands for the ability to view a live event in person, and at the same time, on a personal device so they can see the players from different viewing angles, with statistics, social media options or other forms of interactivity built into the screen/experience.

The 5G reference design provides the necessary infrastructure for CSPs to program their network and provide the necessary connectivity and bandwidth to support the ultra-low latency needed for these types of applications.

To support this ultra-low latency and maximize throughput, Intel's FlexRAN and NEV SDK software leverages the best from the open source community, while taking advantage of integrated Intel technologies for networking. Specifically, FlexRAN software uses Intel Architecture CPU instructions to accelerate operations used in 5G algorithms, while further acceleration is provided with Intel FPGA hardware acceleration in the IA-based hardware platform. By utilizing the open source Data Plane Development Kit (DPDK) for packet processing, data speeds can be increased eight-fold.

Intel Quick Assist Technology (Intel QAT) can also be implemented on chip or via add in card and can free up processor resources by providing crypto acceleration and compression capabilities.

## Use case 2: end-to-end network slicing for enabling new revenue streams

Network slicing is the cornerstone of the 5G architecture that enables the support of diverse 5G services. Essentially, a network slice is a logical network that serves a defined business need with a particular set of characteristics, and comprises all the required network resources, which are configured and connected to each other. Network resources can be physical or virtual, and either dedicated to a particular slice or shared between slices. Network slicing enables CSPs to provide dedicated logical/virtual networks to support specific service requirements that address the specific requirements of use cases, services, industries and customers.

Multiple network slices share the same physical network infrastructure, control and support systems, but are distinct and isolated one from the other. This isolation is essential for providing guaranteed resources for mission-critical applications, with critical traffic dedicated to a particular network slice, or special properties such as low latency, lower cost or massive scaling of the network slice. The provisioning of network slices utilizes NFV and SDN technologies to abstract the physical infrastructure from the logical network architecture.

Amdocs NFV powered by ONAP plays an extensive role in orchestrating and automating the creation, modification and lifecycle management of the individual services and their network slices, while also handling the assignment of the underlying resources by the network infrastructure. With the end-to-end network slice spanning across the RAN, edge, core and transport network, Amdocs NFV powered by ONAP orchestrator is hierarchically positioned at the top of the end-to-end network. It is integrated with the core, edge, RAN, data centers, infrastructure controllers and functions managers to coordinate the end-to-end network operations and services.

**Amdocs NFV powered by ONAP E2E network slicing orchestration**

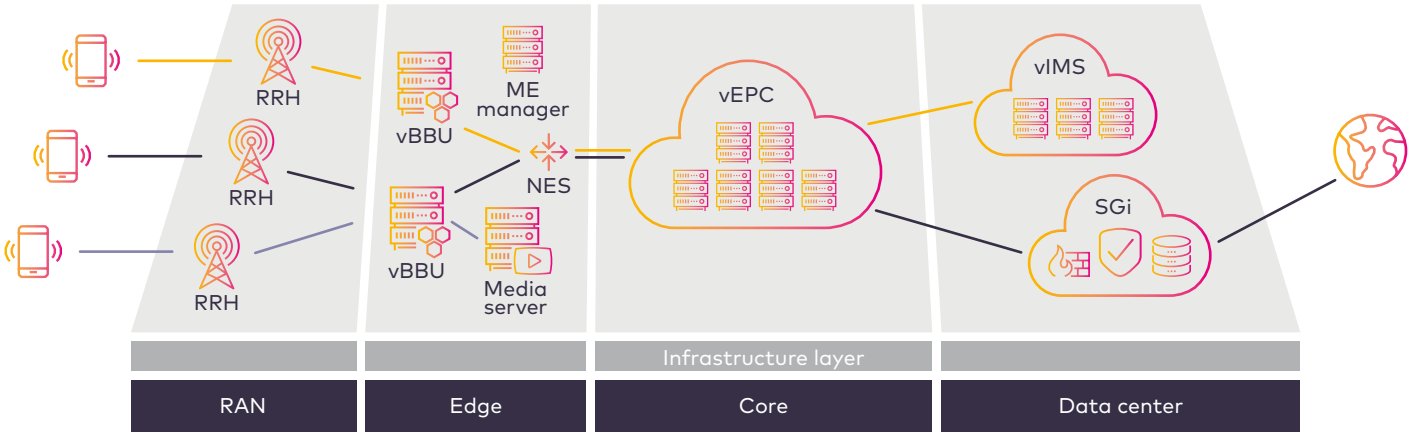


Figure 5: End-to-end network slicing service lifecycle automation and orchestration

To simplify the creation and lifecycle management of network slices, Amdocs NFV powered by ONAP uses TOSCA-based templates. These represent the end-to-end VNFs and PNFs across the different network domains, as well as their policy and service assurance configurations.

The combination of network slicing templates with platform modularity and programmability, enables significantly shorter time to market, as well as cost savings when new network slices need to be provisioned. This is made possible by the ability to reuse building blocks from existing network slices or to replace them with other VNFs in the catalog and perform any necessary changes to meet the new network slice requirement. Because new services are created within a dedicated network slice, the service creation time is simplified, and the isolated nature of network slices reduces the risk that the new service will impact any other service sharing the same resources.

Amdocs NFV powered by ONAP is integrated with the CSP's BSS and expose the network slice templates to the services catalog so that service offers can be created and ordered by customers. Once a customer orders the service or the CSP decides to launch a new service, the BSS triggers Amdocs NFV powered by ONAP to activate the service. This is done by instantiation of all the end-to-end network and radio entities and resources allocated to the service network slice.

Amdocs NFV powered by ONAP is responsible for automating the process of provisioning and modifying network slices and services, ensuring that all VNFs that constitute each network slice are deployed based on the specific service requirements that the network slice is expected to provide. The platform's closed-loop service automation ensures these VNFs will scale on demand to accommodate changes in service and performance requirements. In a virtualized network, the NFV orchestrator is required to coordinate the coexistence of network slices and to make sure the required resources are available for each one, from the centralized core all the way to the RAN.

When the network is congested, Amdocs NFV powered by ONAP orchestrator intervenes to prioritize traffic at the slice level as dictated by policy, requirements or any rule set by the operator, following automated instructions in real time.

# summary

Enabling 5G to fulfil on its promise requires transforming the network into a software-programable network. Virtualization, which traditionally occurred in the back end and core, is increasingly moving toward the RAN and network edge. This transformation creates the need for end-to-end service orchestration across the multiple network domains. Together, orchestration and automation utilize network resources more efficiently and minimize manual processes, thereby promoting network agility, flexibility and lower OPEX.

However, to efficiently monetize 5G use cases, CSPs must enable their business enablement systems to take advantage of the business and operational benefits of their open virtualized network. By implementing a multi-domain, end-to-end network services automation, orchestration and intelligence platform that resides in a service-driven layer, CSPs can integrate the network with business enablement and operational systems (BSS/OSS), thereby making the network service-aware and agile as opposed to the legacy focus on connectivity and capacity.

Amdocs, Intel and Mavenir have partnered to develop pre-integrated, commercially-available components based on the Intel 5G infrastructure reference design blueprint. These form a fully integrated solution comprising the virtualization platform, vRAN radio and vBBU elements, vEPC, server hardware and Amdocs NFV powered by ONAP.  Within this solution, Amdocs NFV powered by ONAP provides the end-to-end service automation and orchestration, managing the lifecycle of individual services and their network slices, while also handling the assignment of the underlying resources by the network infrastructure.

With an emphasis on carrier-grade reliability, dynamic scalability, optimized resource utilization and predictable performance, as well as the ability to quickly launch new services through network slicing and service chaining, the pre-integrated solution enables CSPs to reduce time to market. It achieves this by shortening the development timeframes required to implement a software-defined, cloud-enabled, agile 5G-ready network that supports use cases that include virtual, merged and augmented reality, smart retail, industrial automation, IoT, and cloud gaming.

# about the partners

## About Amdocs

Amdocs is a leading software and services provider to communications and media companies of all sizes, accelerating the industry's dynamic and continuous digital transformation. With a rich set of innovative solutions, long-term business relationships with 350 communications and media providers, and technology and distribution ties to 600 content creators, Amdocs delivers business improvements to drive growth. Amdocs and its 25,000 employees serve customers in over 85 countries. Listed on the NASDAQ Global Select Market, Amdocs had revenue of $3.9 billion in fiscal 2017.

## About Intel: Intel (NASDAQ: INTC)

You may know us for our processors. But we do so much more. Intel invents at the boundaries of technology to make amazing experiences possible for business and society, and for every person on Earth.Harnessing the capability of the cloud, the ubiquity of the Internet of Things, the latest advances in memory and programmable solutions, and the promise of always-on 5G connectivity, Intel is disrupting industries and solving global challenges. Leading on policy, diversity, inclusion, education and sustainability, we create value for our stockholders, customers, and society. Information about Intel can be found at **newsroom.intel.com** and **www.intel.com**.

## About Mavenir

Mavenir is purpose-built to redefine mobile network economics for Communication Service Providers. Our innovative solutions pave the way to 5G with 100% software-based, end-to-end, Cloud Native network solutions. Leveraging industry-leading firsts in VoLTE, VoWiFi, Advanced Messaging (RCS), Multi-ID, vEPC and Cloud RAN, Mavenir accelerates network transformation. For more information, visit **www.mavenir.com**.

## About Radisys

Radisys' open telecom solutions enable service providers to drive disruption with new open architecture business models, while accelerating their time-to-market for new services. Radisys' disaggregated and virtualized enabling technologies – pre-integrated with Intel's FlexRAN 5G solution based on x86 and FPGA – support innovative use cases for 5G, virtualized RAN, IoT, and edge computing applications. For more information, visit **www.radisys.com**.

## About Wind River

Wind River® is the world leader in embedded software solutions for the telecommunications and communications industries. Wind River offers a comprehensive, end-to-end portfolio of solutions for secure and managed intelligent devices at the edge, to the gateway, into the critical network infrastructure, and up into the cloud. For more information, visit **www.windriver.com**.

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